THE HEAT-CENTRE IN THE BRAIN.

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TWENTY years ago it was announced by Tscheschichin that a heat-centre existed above the pons Varolii in the brain. Prof. H. C. Wood, in his large work on fever, has also by numerous experiments arrived at the same conclusion regarding the presence of a cerebral heat-centre. Richet[1] also discovered that the anterior part of the brain had an influence on the temperature of the body. The position of this centre was not located till I published a communication,[2] April 2d, 1884, stating that it was about the corpora striata. Drs. Aronsohn and Sachs[3] in December, 1884, discovered that puncture in the brain caused an increase of the temperature of the body. On July 4th, 1885, I published a preliminary communication,[4] stating that the heat-centre could be localized at the anterior inner end of the optic thalami and that the increase of temperature was due to increased production of heat. On Oct. 29th, 1885, Drs. Sachs and Aronsohn[5] published a paper stating that the heat-centres were more accurately localized in the nodus corsorius and the tissues about the corpus striatum, and that the increase of temperature was due to increased heat-production. In this paper I propose to give the experiments upon which the preliminary note was based.

Forty experiments were made upon rabbits. The ani-

[1] Bulletins de la Société de Biologie, March 29th, 1884.
[2] Journal of Nervous Diseases, April, 1884.
[3] Deutsche Medicinische Wochenschrift, No. 51, 1882.
[4] Philadelphia Medical News, July, 1885.
[5] Pflüger's Archiv.

mal was bound down, the scalp divided and the skull trephined, the dura mater divided, and punctures made through the brain by means of a small spear-pointed instrument two millimetres in diameter at the point and the remaining part one millimetre in thickness. The temperature-variations were noted by means of a rectal thermometer. The animal during this time was permitted to run about the laboratory. Punctures were also made upwards through the base of the brain by means of a stiff probe which passed through the skull by pressure. After all these punctures the animal was killed, the brain removed, hardened in alcohol, and sections made. To estimate heat-production, d'Arsonval's copper-calorimeter, surrounded by means of felt and feathers, was employed. The temperature of the calorimeter was noted by means of a thermometer inserted into the water contained in its closed cavity. Another thermometer inserted into the exit tube gave the temperature of the air aspirated from the calorimeter by means of the large meter of the Voit-respiration apparatus, which is run by a water-wheel. The temperature of the air of the room was also noted. The calorimeter was used when its temperature was a few degrees below that of the air. The large meter registered the amount of air passing through the meter. The calculations were made in the manner detailed in Wood's work on fever. All thermometers were corrected before the estimates were made. If the appended experiments are examined, it will be seen that at the anterior inner end of the optic thalamus a puncture causes a great increase of temperature in Exp. 12, almost 7° F. in an hour. That this rise of temperature continues on the following day is seen in several experiments, as in Exp. 8.

The calorimeter experiments show that the increments of temperature are due to increased production of heat and not to diminished dissipation.

In Exp. 16, the increase was 11.13 units; in Exp. 17, 10.49 units. In the calorimeter experiments, a great increase of temperature was not obtained, otherwise the units of heat-production would be much greater. Many

other calorimetrical experiments were made, but I do not think it necessary to publish them, as they are only confirmatory of those noted. Electric irritation by means of Du Bois-Reymond's inductorium caused an increase of temperature. It was also found that Fairchild's trypsin when dissolved in water with a small quantity of bicarbonate of soda and filtered, that the filtrate injected by the jugular caused a rise of temperature of four degrees in the rabbit.

These experiments prove that at the anterior inner end of the optic thalami a puncture causes an increase of temperature due to increased heat-production. Fig. A—1 shows about the point that the puncture should be made to cause the greatest increase of temperature; 2, is the corpus striatum; 3, optic thalamus; 4, corpora quadri-

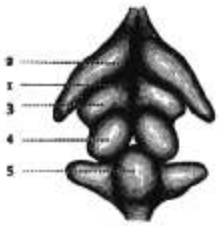

FIG. A.

gemina; 5, cerebellum. The cut was drawn by my student, Mr. Carter, from the brain of a rabbit.

Experiments made during last summer show that the tissues between the optic thalami and corpora striata along the median line also cause an increase of temperature, especially at the point which Schiff has pointed out as causing upon injury in rabbits a peculiar cry.

We have here an artificial fever due entirely to nervous disturbance, and not to any poisons circulating in the blood. The rise of 7° F. in an hour shows that the nervous system plays a very extended part in the phenomena of fever. As to the nature of these centres, all opinions are more or less conjectural. With our present information on other functions of the brain, the inference is that they are inhibitory in their nature.

I am indebted to my student, Mr. Peter J. Martin, for the calorimetrical determinations.

Exp. 1.

Rabbit received a puncture through the anterior inner part of the right corpus striatum.

		T.
2.	P.M.,	103¾
2.15	"	104
3.	"	105 1/10
4.	"	104½

Animal killed.

Exp. 2.

Rabbit. Lesion about the centre of the left optic thalamus.

			T.
1.45	P.M.,		102½
3.46	"	Puncture in thalamus,	104⅞
5.	"		105⅞

Exp. 3.

Rabbit.

			T.
1.25	P.M.,		102½
2.45	"	Puncture in right corpus striatum to the base of the brain.	
3.45	"		105 1/10
1.30	" next day		102½

Exp. 4.

Rabbit.

			T.
2.10	P.M.,		103½
2.15	"	Puncture in left corpus striatum.	
3.	"		105½

Exp. 5.

Rabbit.

			T.
1.30	P.M.,		103½
1.35	"	Puncture at the anterior inner part of the optic thalamus just where it lies against the corpus striatum.	
			106 1/10

Exp. 6.

Rabbit.

		T.
1.35 P.M.,	. . . . .	103½
3.30 "	Puncture in anterior inner edge of thalamus,	105½

Exp. 7.

Rabbit.

		T.
2.07 P.M.,	. . . . .	103¾
6.30 "	Edge of thalamus injured at its anterior part,	105¾

Exp. 8.

Rabbit.

		T.
2.07 P.M.,	. . . . .	104 1/10
3. "	Puncture at anterior inner part of thalamus.	
6.30 "	. . . . .	108½
10.45 A.M., next day,	. . . . .	107⅛

Exp. 9.

Rabbit.

		T.
1 M.,	. . . . .	103¾
1.40	Lesion at anterior inner part of thalamus.	
4. "	. . . . .	109¼

Exp. 10.

Rabbit.

		T.
1.43 P.M.,	. . . . .	105 7/10
1.44 "	Needle electrodes pushed into the brain; Du Bois coil at 23 centimetres for ten seconds; the points were in the corpus striatum and the anterior inner edge of the thalamus.	
1.48 P.M.,	. . . . .	106
3. "	. . . . .	107⅛

Exp. 11.

Rabbit.

		T.
3.40 P.M.,	. . . . .	103⅛
	Puncture in the optic thalamus.	
5.47 "		104⅛

Exp. 12.

Rabbit.

		T.
1.45 P.M.,	. . . . .	102⅛
1.55 "	Puncture through the base of brain where optic thalami join.	
2.25 P.M.,	. . . . .	104½
2.45 "	. . . . .	109⅝
5.15 "	. . . . .	109½

Exp. 13.

Rabbit.

		T.
1.55 P.M.,	. . . . .	103½
	Puncture at base of brain through anterior end of optic thalamus.	
2.26 P.M.,	. . . . .	104⅝

Exp. 14.

Rabbit.

		T.
3.10 P.M.,	. . . . .	103⅛
3.15 "	Puncture through base of brain, through the anterior ends of optic thalami.	
5.15 P.M.,	. . . . .	106

Exp. 15.

Rabbit.

		T.
1.20 P.M.,	. . . . .	103½
1.30 "	Puncture through base of thalamus on left side.	
2.30 "	. . . . .	107

For every degree the calorimeter is below that of the air, a correction of $\frac{9}{100}$° F. is made for the rise of temperature of the calorimeter during the experiment. It was found by several experiments that the calorimeter normally rose this much every hour, when a definite quantity of air was drawn through the calorimeter.

Exp. 16.

TIME.	A.T.	E.T.	C.T.	R.T.	M.
1.27	71.8	70.1	70.4	103$\frac{1}{10}$	583,736
1.42	72.4	72.7	70.6		

1.57	72.5	72.7	70.8		
2.12	72.7	72.7	70.9		
2.27	72.8	72.7	71.	$102\frac{1}{5}$	588,116
	72.4	72.1	.6	.5 loss.	4,380
2.58	73.8	70.8	71.2	$103\frac{1}{10}$	
3.13	73.3	73.4	71.4		
3.28	73.3	72.7	71.5		
3.43	73.3	72.7	71.6		
3.58	73.4	73.4	71.8	$106\frac{1}{2}$	592,986
	73.5	72.6	.6	$3\frac{1}{10}$ gain.	4,870

Wt. 3.90 lbs. Lesion ant. part of thalamus.

$V+(V\times t'\times 002035) = V'$

$V' = 4380$ litres $\times 61.028 = 26730.26 \div 1728 = 154.6$ cubic feet.

$t' = 72.1^\circ - 32^\circ = 40.1 \times .002035 = .0816$.

$V + .0816\ V = 154.6$ cubic feet.

$$V = \frac{154.6}{1.0816} = 142.9 \text{ cu. ft. at } 32^\circ \text{ F.}$$

$W = 142.9 \times .08073 = 11.55$ lbs. = weight of air.

$Q = w \times t \times$ sp. h.

$11.55 \times .3 \times .2374 = .820$ = heat from air.

$41.72 \times (.6 - .16) = 18.356$ = heat to calorimeter.

17.536 = heat dissipation.

After Operation.

$V' = 4870$ litres $\times$ 61.028 cu. in. $= 29722.63 \div 1728 = 172.0$ cu. ft.

$t' = 72.6 - 32 = 40.6 \times .002035 = .0826$.

$V + .0826\ V = 172.0$ cu. ft.

$$V = \frac{172.0}{1.0826} = 158.8 \text{ cu. ft. at } 32^\circ \text{ F.}$$

$w = 158.8 \times .08023 = 12.8$ lbs. = weight of air.

$Q = w \times t \times$ sp h.

$12.8 \times 9 \times .2374 = 2.720$ = heat taken from air.

$41.72 \times (.6 - .15) = 18.774$ = heat to calorimeter.

16.050 = heat dissipation.

Heat Production.

Q = w+t+sp. h. W. 3.9 lbs.
Loss of temperature per hour, .5°.
3.9+.5+.83 = 1.615 = heat from reserve.
17.536 = heat dissipation.
15.921 = hourly production.

After Operation.

Gain of temperature per hour, 3.4°.
3.9+3.4+83 = 11.00 = heat to reserve.
16.05 = heat dissipation.
27.05 = hourly production.

Exp. 17.

TIME.	A.T.	E.T.	C.T.	R.T.	M.
1.35	80.9	76.4	76.5	102⅜	628,846
1.50	81.3	78.8	76.8		
2.05	81.6	79.1	77.		
2.20	81.7	79.1	77.1		
2.35	81.8	79.1	77.3	102⅜	634,646
	81.4	78.5	.8	0	5,800
2.54	82.4	77.7	77.5	102⅜	
3.9	82.4	80.2	77.8		
3.24	82.4	80.2	78.		
3.39	82.5	80.	78.2		
3.54	82.5	80.	78.4	104	639,867
	82.4	79.6	.9	1⅜	5,221

Wt. 3.34 lbs. Lesion in the optic heat-centre.

$V+(v\times t'\times 002035) = V'$
$V' = 5800$ litres $\times 61.028 = 35396.24 \div 1728 = 204.0$ cu. ft.
$t' = 78.5-32 = 46.5\times 002035 = .0946.$
$V+.0946\ V = 204.0$ cu. ft.
$V = \frac{204.0}{1.0946} = 18.64$ cu. ft. at 32° F.
$w = 18.64\times .08073 = 15.0$ lbs. = weight of air.
$Q = w\times t\times$ sp. h.

15.0×2.9×.2374 = 11.40 = taken from air.
41.72×(.8−.36) = 18.35 = heat to calorimeter.

6.95 = heat dissipation.

After Operation.

V′ = 5221 litres×61.028 = 31856.51÷1728 = 184.3 cu. ft.
t′ = 79.6−32 = 47.6×.002035 = .0968.
V+.0968 V = 184.3 cu. ft.

$$V = \frac{184.3}{1.0968} = 16.80 \text{ cu. ft. at } 32^\circ \text{ F.}$$

W = 16.80×.08073 = 13.5 lbs. = weight of air.
Q = w×t×sp. h.
13.5×2.8×.2374 = 8.960 = taken from air.
41.72×(.9−.36) = 22.528 = heat to calorimeter.

13.568 = heat dissipation.

Heat Production.

Q = w×t×sp. h. W. 3.34 lbs.
No change of temperature.
Heat dissipation = 6.95 = hourly production.

After Operation.

Gain of temperature per hour, 1.4° F.
3.34×1.4°×83 = 3.881 = added to reserve.
13.568 = heat dissipation.

17.449 = heat production.

Exp. —

TIME.	A.T.	E.T.	C.T.	R.T.	M.
1.25	72.6	71.6	72.2	103⅛	617,667
1.40	72.7	73.7	72.4		
1.55	72.9	74.4	72.5		
2.10	73.2	74.4	72.7		
2.25	73.5	74.9	72.8	102⅜	623,073
	72.7	73.8	.6	1⅛ loss.	540.6

4.10	76.9	74	73.3	103⅞	
4.25	77.4	74.9	73.5		
4.40	77.4	75.9	73.7		
4.55	77.8	75.9	73.9		
5.10	78.2	76.2	74.1	104⅛	628,846
	77.5	75.4	.8	⅛ gain.	577.3

Wt. 3.35 lbs. Lesion in corpus striat. and optic thalamus.

$V+(v\times t\times .002035) = V'$

$V' = 5406 \text{ litres} \times 61028 = 329551.2 \div 1728 = 190.6$ cu. ft.

$t = 73.8-32 = 41.8\times .002035 = .085.$

$V+.085V = 190.6$ cu. ft.

$$V = \frac{190.6}{1.085} = 179.7 \text{ cu. ft. of air at } 32^\circ \text{ F.}$$

$w = 179.7\times .08073 = 14.5$ lbs. = weight of air.

$Q = w\times t\times$ sp. h.

$14.5\times 1.1\times .2374 = 3.780$ = heat added to air.

$41.72\times .6 = 25.032$ = heat to calorimeter.

28.810 = heat dissipation.

After Operation.

$V' = 577.3\times 61.028 = 352131.5 \div 1728 = 203.8$ cu. ft.

$t = 75.4-32 = 43.4\times .002035 = .0883.$

$V+.0883V = 208.3$ cu. ft.

$$V = \frac{208.3}{1.0883} = 191.4 \text{ cu. ft. at } 32^\circ \text{ F.}$$

$W = 191.4\times .08073 = 15.4$ lbs. = weight of air.

$Q = w\times t\times$ sp. h.

$15.4\times 2.1\times .2374 = 7.660$ = heat from air.

$41.72\times (.8-.31) = 20.442$ = heat to calorimeter.

12.782 = heat dissipation.

Heat Production.

$I = w+t+$ sp. h. $W = 3.35$ lbs.

Loss of temperature per hour, 1.2°

3.35 + 1.2 + .83 = 3.33 taken from reserve.
28.81 = heat dissipation.

25.48 = hourly production.

After Operation.

Gain in temperature per hour, 8°
3.35 + .8 + .83 = 2.22 = added to reserve.
12.78 = heat dissipation.

14.98 = hourly production.